# Utah Department of Environmental Quality
# Division of Water Quality
# TMDL Section
# Beaver River Watershed TMDL

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|---|---|
| **Waterbody ID** | **Beaver River** |
| **Location** | **Beaver County, Southwest Central Utah** |
| **Pollutants of Concern** | **Total Phosphorus, Noxious Aquatic Plants and Riparian Habitat Alteration** |
| **Impaired Beneficial Uses** | **Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.** |
| **Loading Assessment**<br>**Current Load**<br>**TMDL Target Load**<br>**Load Reduction** | <br>**6589 kg/yr**<br>**2353 kg/yr**<br>**4236 kg/yr** |
| **Defined Targets/Endpoints** | **- Develop 80 Animal Waste Mgt. Systems**<br>**- 0.05 mg/L total phosphorus concentration**<br>**- Shift from blue-green algal dominance (noxious aquatic plants)**<br>**- Shift from sediment and organic enrichment tolerant macroinvertebrates in Beaver River**<br>**- Stabilize 24 miles of streambank and restore 65 miles of riparian areas along Beaver River** |
| **Implementation Strategy** | **Develop Comprehensive Nutrient Management Plans**<br>**Improve irrigation efficiency**<br>**Install instream structures to protect streambanks**<br>**Establish filter strips of vegetation in riparian areas**<br>**Implement best grazing management principles** |
| **This document is identified as a TMDL for waters in the Beaver River drainage and is officially submitted to U.S. EPA to act upon and approve as TMDLs for those waters.** | |

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|---|---|
| **Waterbody ID** | **Minersville Reservoir** |
| **Location** | **Beaver County, Southwest Central Utah** |
| **Pollutants of Concern** | **Total Phosphorus, Dissolved Oxygen and Temperature** |
| **Impaired Beneficial Uses** | **Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.** |
| **Loading Assessment**<br>**Current Load**<br>**TMDL Target Load**<br>**Load Reduction** | <br>**8906 kg/yr**<br>**2719 kg/yr**<br>**6187 kg/yr** |
| **Defined Targets/Endpoints** | **- Develop 80 Animal Waste Mgt. Systems**<br>**- 0.025 mg/L total phosphorus concentration**<br>**- Trophic State Index value of 40-50**<br>**- Shift from blue-green algal dominance (noxious aquatic plants)**<br>**- No grazing below Minersville Res. high water line**<br>**- Dissolved oxygen > 4.0 mg/L one day average (for >50% of water column)** |
| **Implementation Strategy** | **Develop Comprehensive Nutrient Management Plans**<br>**Improve irrigation efficiency**<br>**Install instream structures to protect streambanks**<br>**Establish filter strips of vegetation in riparian areas**<br>**Implement best grazing management principles** |
| **This document is identified as a TMDL for waters in the Beaver River drainage and is officially submitted to U.S. EPA to act upon and approve as TMDLs for those waters.** | |

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|---|---|
| **Waterbody ID** | **Puffer Lake** |
| **Location** | **Beaver County, Southwest Central Utah** |
| **Pollutants of Concern** | **Dissolved Oxygen** |
| **Impaired Beneficial Uses** | **Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.** |
| **Loading Assessment**<br>**Current Load**<br>**TMDL Target Load**<br>**Load Reduction** | <br>**15 kg/yr**<br>**19 kg/yr**<br>**none required** |
| **Defined Targets/Endpoints** | **- 0.025 mg/L total phosphorus concentration**<br>**- Trophic State Index value of 40-50**<br>**- Shift from blue-green algal dominance (noxious aquatic plants)**<br>**- Dissolved oxygen > 4.0 mg/L one day average (for >50% of water column in lakes)** |
| **Implementation Strategy** | **Improved Grazing Management Systems**<br>**Recreational Use Best Management Practices**<br>**Roads Maintenance** |
| **This document is identified as a TMDL for waters in the Beaver River drainage and is officially submitted to U.S. EPA to act upon and approve as TMDLs for those waters.** | |

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| **Waterbody ID** | **LaBaron Reservoir** |
| **Location** | **Beaver County, Southwest Central Utah** |
| **Pollutants of Concern** | **Dissolved Oxygen and pH** |
| **Impaired Beneficial Uses** | **Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.** |
| **Loading Assessment**<br>**Current Load**<br>**TMDL Target Load**<br>**Load Reduction** | <br>**11 kg/yr**<br>**5 kg/yr**<br>**6 kg/yr** |
| **Defined Targets/Endpoints** | **- 0.025 mg/L total phosphorus concentration**<br>**- Trophic State Index value of 40-50**<br>**- Shift from blue-green algal dominance (noxious aquatic plants)**<br>**- Dissolved oxygen > 4.0 mg/L one day average (for >50% of water column in lakes)** |
| **Implementation Strategy** | **Improved Grazing Management Systems**<br>**Recreational Use Best Management Practices**<br>**Roads Maintenance**<br>**Construction Site Best Management Practices** |
| **This document is identified as a TMDL for waters in the Beaver River drainage and is officially submitted to U.S. EPA to act upon and approve as TMDLs for those waters.** | |

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|---|---|
| **Waterbody ID** | **Kents Lake** |
| **Location** | **Beaver County, Southwest Central Utah** |
| **Pollutants of Concern** | **Total Phosphorus, Dissolved Oxygen and pH** |
| **Impaired Beneficial Uses** | **Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.** |
| **Loading Assessment**<br>**Current Load**<br>**TMDL Target Load**<br>**Load Reduction** | <br>**79 kg/yr**<br>**20 kg/yr**<br>**59 kg/yr** |
| **Defined Targets/Endpoints** | **- 0.025 mg/L total phosphorus concentration**<br>**- Trophic State Index value of 40-50**<br>**- Shift from blue-green algal dominance (noxious aquatic plants)**<br>**- Dissolved oxygen > 4.0 mg/L one day average (for >50% of water column in lakes)** |
| **Implementation Strategy** | **Improved Grazing Management Systems**<br>**Recreational Use Best Management Practices**<br>**Roads Maintenance** |
| **This document is identified as a TMDL for waters in the Beaver River drainage and is officially submitted to U.S. EPA to act upon and approve as TMDLs for those waters.** | |

# Beaver River Watershed TMDL Executive Summary

This document addresses water quality impairments within the Beaver River Watershed through the establishment of Total Maximum Daily Loads (TMDLs) for the pollutants and stressors of concern. The purpose of this TMDL is to improve water quality and protect or restore designated beneficial uses. The Beaver River, Minersville Reservoir, and three small lakes in the upper watershed, Puffer Lake, LaBaron Reservoir, and Kents Lake are listed on the State's 303D list of impaired waters. All of these waterbodies have been designated as not meeting their cold water fishery beneficial use due to excess total phosphorus, noxious aquatic plants (blue-green algae), riparian habitat alteration, low dissolved oxygen, and temperature. Sources of impairment originate from agricultural activities, urban runoff, summer home development and recreational activities. There are no permitted point source discharges in the watershed.

The Beaver River Watershed is located in the southwest-central part of the State of Utah and encompasses 500 square miles. Elevations range from over 12,000 feet on Delano Peak and Mount Belknap to 5500 feet at Minersville Reservoir. Vegetation is characteristic of the Great Basin with coniferous forests dominating the high elevations, Pinyon-Juniper forests at mid-elevations and sagebrush-grass or agricultural lands in the bottom. The Beaver River is the primary drainage in the watershed flowing from the Tushar Mountains to the east, through Beaver City and into Minersville Reservoir twelve miles to the west. Flows in the Beaver River vary widely due to spring snow melt, irrigation diversions, and occasional thunderstorms. In early summer stream flows average 114 cubic feet per second (cfs), 15 cfs during the winter and 50 cfs during irrigation season.

Approximately 3000 people reside within the watershed with the majority living in Beaver City. The economy of the watershed is based primarily upon agricultural production of beef cattle and dairy operations. Recreational opportunities on nearby National Forest lands and Minersville State Park provides some revenue from tourism. The transportation of goods is also important to the local economy due to Interstate 15 that runs adjacent to Beaver City.

A Clean Lakes Phase I Study on Minersville Reservoir in 1991-1992 identified the Beaver area as a priority nonpoint source watershed. Recognizing the need for improving the environmental quality of their community a local Watershed Steering Committee was formed to develop a Coordinated Resource Management Plan under the leadership of the Beaver Soil Conservation District. This TMDL will be included as a chapter in the plan to guide the implementation of resource improvements and ensure that beneficial uses are attained through a voluntary incentive based program.

Implementation goals adopted by the Beaver River Watershed Steering Committee include: develop a minimum of 80 comprehensive nutrient management plans for animal feeding areas; eliminate grazing below the high water line for impaired reservoirs; manage pasture grazing to minimize phosphorus runoff potential; treat tailwater for removal of sediment and phosphorus; improve irrigation delivery systems on 4,000 acres of land; restore and protect riparian corridors by streambank stabilization and habitat improvement; and increase vegetative cover and diversity and enhance soil stability for rangelands. Implementation of the proposed controls will be completed in phases to permit monitoring and evaluation of their effectiveness.

Given the variety of pollution sources and their wide distribution throughout the watershed a holistic perspective was used in the establishment of endpoints that will measure progress towards meeting water quality goals and objectives. Established endpoints include conventional water quality parameters, macroinvertebrate composition, biological productivity, stream morphology, and the biological integrity of the stream and its riparian corridor.

Specific endpoints for the Beaver River and tributaries are a shift from organic enrichment and sediment tolerant macroinvertebrates in the lower reach and to protect the existing macroinvertebrate community in the upper reach, total phosphorus concentrations less than or equal to 0.05 mg/L, one day average dissolved oxygen concentrations greater than 4.0 mg/L, the stabilization of 24 miles of streambanks and the restoration of 22 miles of non-functional and 43 miles of at-risk riparian habitat. Specific endpoints for the lakes include a shift away from blue-green algal dominance, in-lake and inflow total phosphorus concentrations equal to or less than 0.025 mg/L and 0.05 mg/L respectively, one day average dissolved oxygen concentrations greater than 4.0 mg/L for 50% of the water column, trophic state index values between 40 and 50, and no grazing below the high water line.

## 1.0 Introduction

This draft TMDL document for the Beaver River Watershed is being submitted under Sec. 303(d) of the Clean Water Act for EPA review and approval. Much of the information contained within this report was derived from the Beaver River Coordinated Resource Management Plan (CRMP). One of the primary intents of the Beaver River CRMP is to document existing resource conditions in the Beaver River watershed and develop a watershed restoration action strategy that will address water quality impairments identified by the local steering committee or the State Division of Water Quality in its Sec. 305(b) report to the U.S. Environmental Protection Agency (EPA) containing Utah's 303(d) list of impaired waters.

The Beaver River Watershed is located approximately 160 miles south of Salt Lake City and 50 miles north of Cedar City and is within the Great Basin hydrologic region (Figure 1). The watershed encompasses approximately 320,000 acres with about 306,000 acres in Beaver County and 14,000 acres in Iron County. The watershed is encircled by the Tushar Mountains on the northeast and east, Circleville Mountain on the southeast, and Black Mountain, Mahogany Knoll and Jack Henry Knoll on the south. The Mineral Mountains are to the west, with Gillies Hill, Woodtic Hill and Wittwer Hill to the north. Beaver City, the county seat, has the highest population within the watershed with an estimated 3,000 residents. Other communities within the watershed include Greenville, Adamsville and Manderfield below Beaver City.

## 1.1 Impaired Waters

The waterbodies on the 1998 impaired waters list (303(d) list) within the Beaver River watershed along with the specific pollutants or stressors linked to their impairment are shown in Table 1.

Table 1 Beaver River Watershed Impaired Waterbodies

| Waterbody Description | Map in Report | Hydrologic Unit Code HUC | Specific Pollutant or Stressor | Impaired Beneficial Use |
|---|---|---|---|---|
| Beaver River and tributaries from Minersville Reservoir to the headwaters | Figure 1 | 16030007 | Total Phosphorus, noxious aquatic plants, temperature, riparian habitat alteration | 3A* |
| Minersville Reservoir | Figure 1 | 16030007 | Total Phosphorus, dissolved oxygen, temperature | 3A |
| Puffer Lake | Figure 2 | 16030007 | Dissolved oxygen | 3A |
| LaBaron Reservoir | Figure 3 | 16030007 | Dissolved oxygen | 3A |
| Kents Lake | Figure 4 | 16030007 | Total Phosphorus, dissolved oxygen | 3A |

Figure 1  Beaver River Watershed

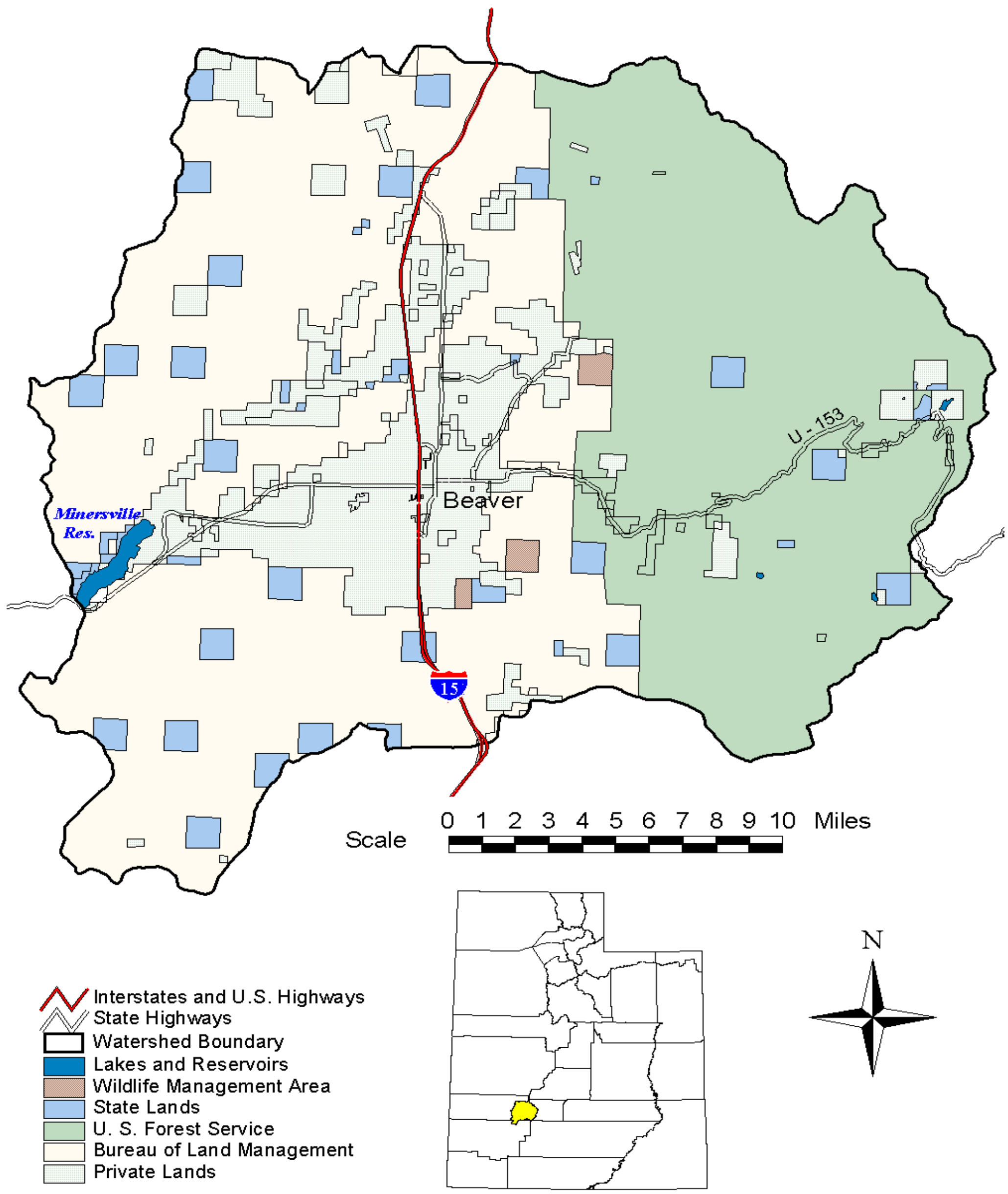


Figure 2 Puffer Lake Subwatershed

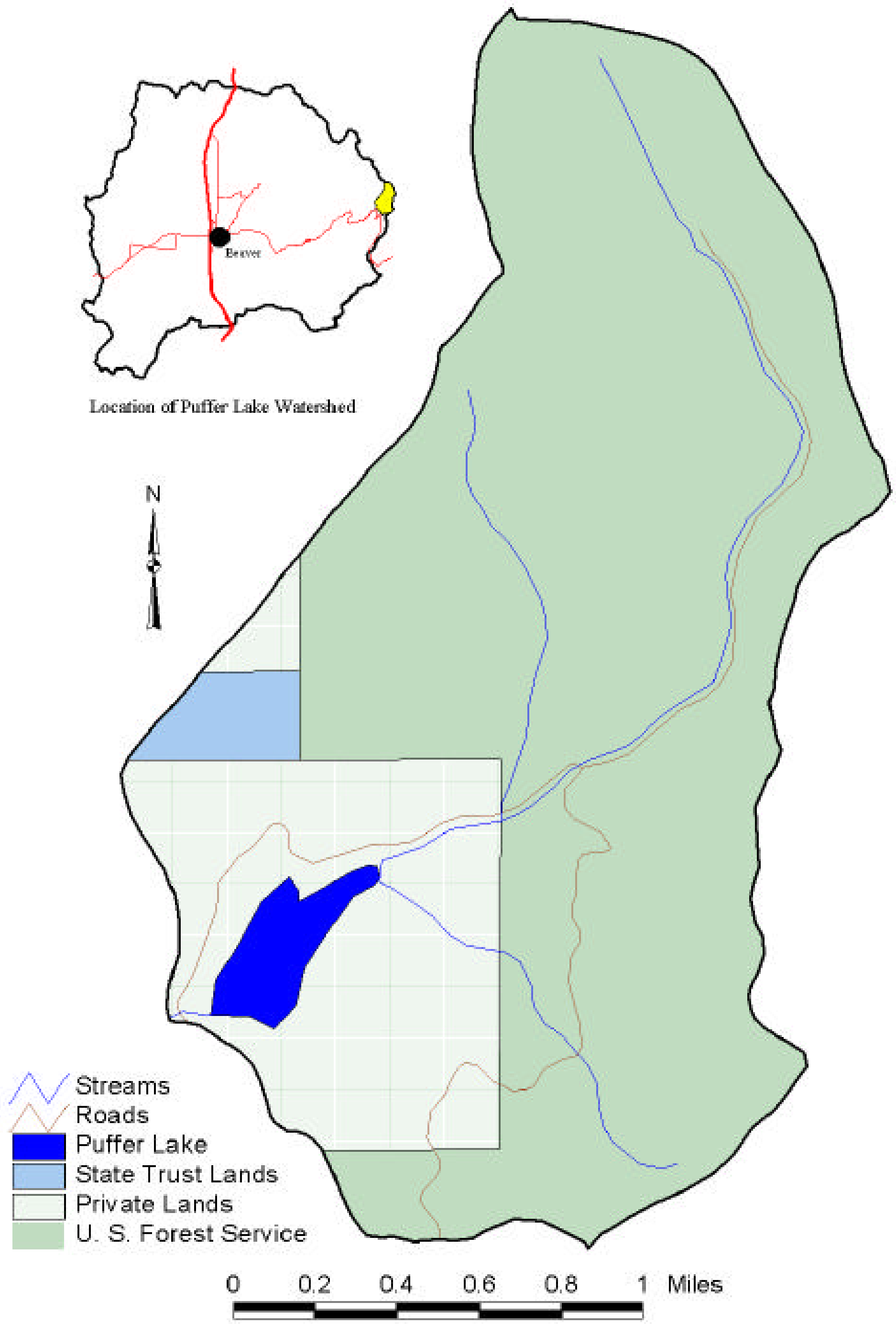


Figure 3  LaBaron Reservoir Subwatershed

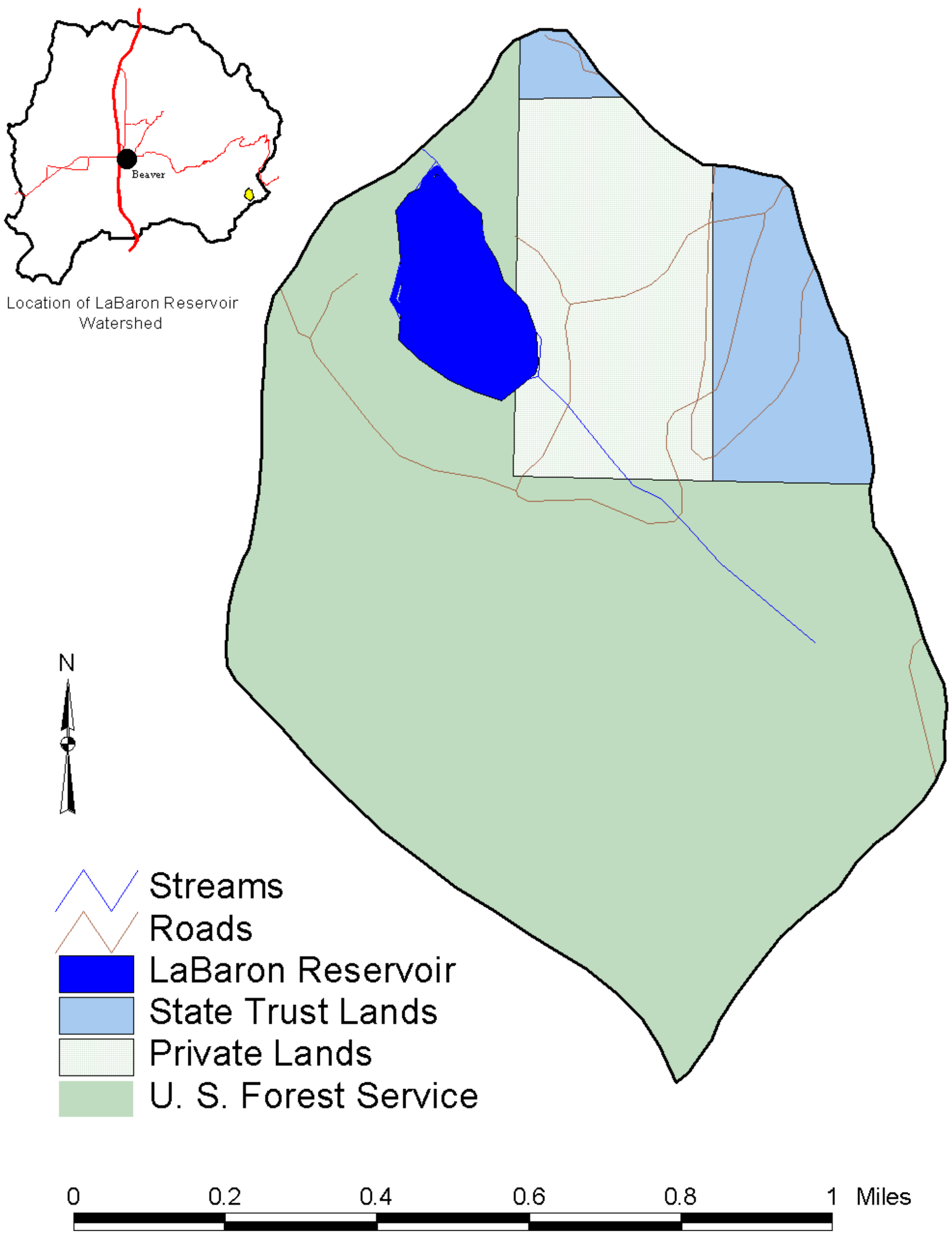
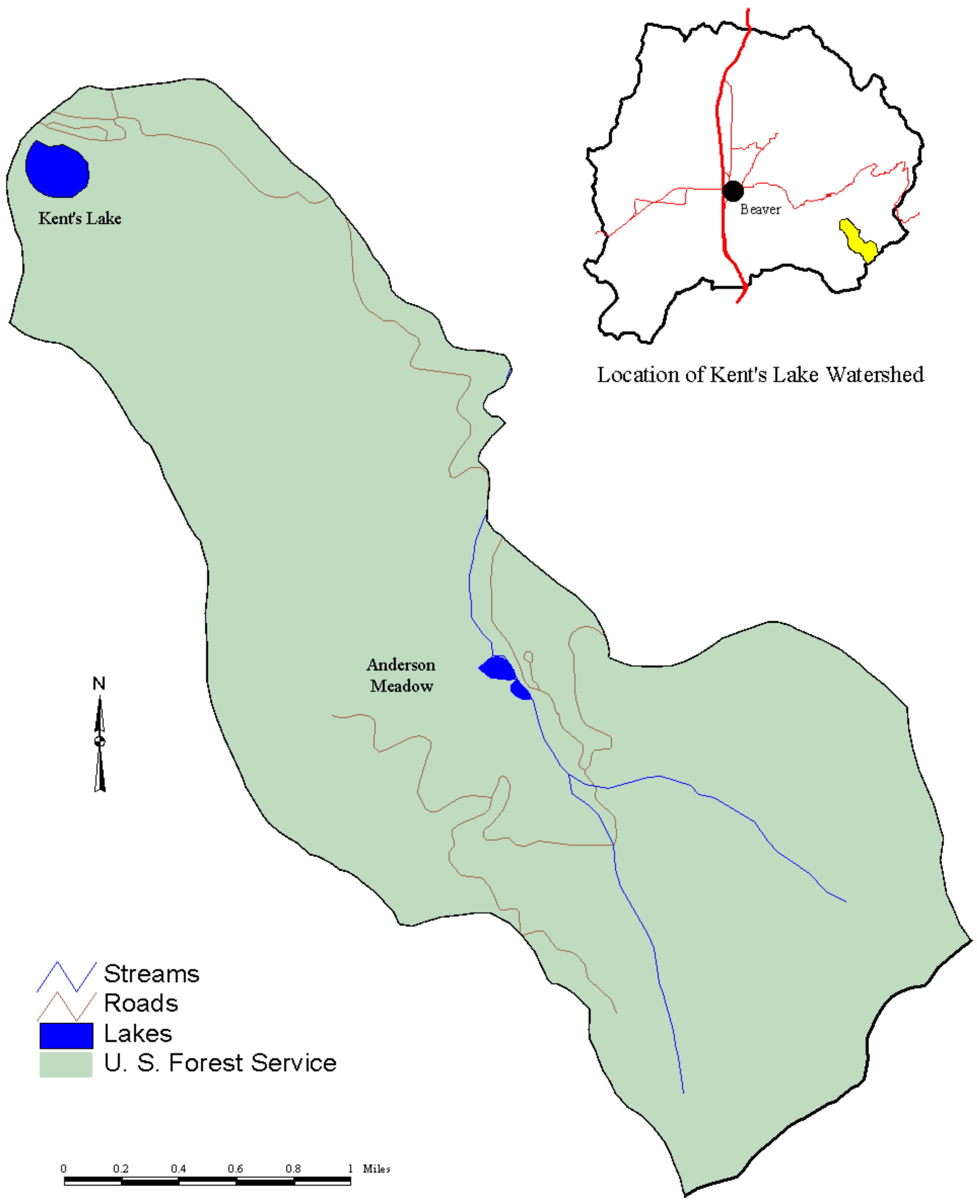


Figure 4  Kents Lake Subwatershed



The completion of Total Maximum Daily Loads (TMDLs) for these water bodies were initially designated as a low priority but the development of a local water quality management plan and the voluntary support of local stewards to address water quality problems in the watershed through an incentive based nonpoint source control program has elevated them to a higher priority. The development of these TMDLs has not disrupted the state's progress towards completing targeted TMDLs. The development of this TMDL and establishment of target endpoints was facilitated by the awarding of a Sec. 319 Non-Point Source (NPS) grant and the availability of sufficient data to model and track phosphorus in the watershed.

### 1.2 Water Quality Standards

This TMDL for the Beaver River Watershed focuses on restoration of beneficial uses and attaining specific numeric criteria associated with Utah's water quality standards. The primary impaired beneficial use is the cold water fishery but concerns related to water clarity and algal production and their impact on recreation is also a concern. Water quality parameters of concern that exceed their numeric criteria include dissolved oxygen, temperature, and total phosphorus. The numeric criteria established for dissolved oxygen, total phosphorus and temperature are explained in "Standards of Quality for Waters of the State" (Utah Administrative Code R317-2). The numeric criteria established for dissolved oxygen is a one day average of 4.0 mg/L for cold water fisheries. The water quality criteria for temperature in cold water fisheries is 20°C. The numeric criteria for total phosphorus is 0.05 mg/L in streams and 0.025 mg/L in lakes. It is important to note that total phosphorus is not a standard but a pollution indicator that is considered along with other corroborating parameters in order to determine if impairment exists. However there is also a narrative standard associated with total phosphorus related to its effect on increased algal production, specifically of blue-green algae. Blue-green algae is synonymous with noxious aquatic plants included in Beaver River's 303(d) list of impairments. Narrative criteria include Carlson Trophic State Index (TSI) values between 40 and 50, and a shift from blue-green algal dominance and sediment and nutrient enhanced tolerant macroinvertebrates.

Stream water quality data used in this analysis is obtained from grab samples gathered throughout the year. Lake water quality data is derived from profile data and water samples taken throughout the water column during the productivity season. Endpoints associated with algal dominance are based on an evaluation of samples taken during the summer.

### 1.2.1 Existing Impairments

The Beaver River has an average annual stream flow of 114 cubic feet per second (cfs) in the early summer, 15 cfs in the winter, and 50 cfs during the irrigation season. Flows from Indian Creek and Wildcat Creek tributaries average 6.5 cfs. Water is diverted from the Beaver River for power generation and agricultural uses at many locations from the headwaters of the river to Minersville Reservoir. The most severe dewatering occurs below the Mammoth Canal diversion at the mouth of the canyon, where sections of the river are totally dewatered at times during the irrigation season. Despite the diversions the Beaver River is able to deliver water into Minersville Reservoir most of the time due to return flow, springs and seepage water. During periods of high runoff, usually in early spring, flows from North Creek and South Creek reach the Beaver River. Water from Wildcat and Indian Creek tributaries usually only reach Minersville Reservoir during periods of very high spring runoff.

Minersville Reservoir is a popular fishery and heavily used recreational facility. It was originally constructed for agricultural purposes in an area where water storage facilities are very limited. The reservoir stores 26,500 acre feet of water with a surface area of 990 acres. According to the Minersville Clean Lakes Report (1995) the reservoir is eutrophic and does not support its designated Class 3A use (protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain). The reservoir exhibits violations of conventional water quality parameters dissolved oxygen and temperature and the state pollution indicator for total phosphorus (0.025 mg/L). The reservoir also has a history of blue-green algal (phytoplankton) dominance and reported fish kills. The TSI values for Minersville Reservoir has consistently exceeded the eutrophic boundary value of 50.00 with an average of 59.75 for the last four 305(b) evaluation periods (1989-96). Additional information is available in the State of Utah Phase I: EPA Clean Lakes Study, Diagnostic and Feasibility Report, Minersville Reservoir (1995) and in the report, Utah’s Lakes and Reservoirs (1997).

Kents Lake, LaBaron Reservoir and Puffer Lake are small lakes located in the upper watershed that are primarily used for irrigation water storage. These lakes are listed for not supporting their cold water fishery beneficial use due to low dissolved oxygen, eutrophic conditions, blue-green phytoplankton dominance, fish kills, and high total phosphorus concentrations (Table 2). The sources of pollutants are not well understood due to the scarcity of data on these lakes but excess nutrients appear to be the major factor. Continued monitoring is needed to evaluate the contributions from all of the potential sources including summer home development, grazing in proximity to the lakes and recreation. Best management practices to remedy these impairments may include zoning ordinances to regulate septic tank developments, restricting grazing in proximity to Minersville Reservoir, and controls on storm water runoff from recreational areas.

Table 2 Summary of criteria for 303(d) listing of lakes

| Description | Dissolved oxygen or temperature exceedances | TSI (greater than 50.00) | Blue-green phytoplankton dominance | Low winter dissolved oxygen or fish kills | High total phosphorus concentrations |
|---|---|---|---|---|---|
| Minersville Reservoir | Yes | 56.29 | Yes | Yes | Yes |
| Kents Lake | Yes | 63.92 | Yes | Yes | Yes |
| LaBaron Reservoir | Yes | 60.04 | Yes | Yes | Yes |
| Puffer Lake | Yes | 38.80 | Yes | Yes | |

### 1.3 Public Participation

A locally led watershed steering committee under the leadership of the Beaver Soil Conservation District was essential to assure realization of long-term objectives to restore water quality. After the organization of the Beaver River Technical Advisory Committee (BRTAC) under the direction of the steering committee a public scoping meeting was held to define issues and problems from all the stewards in the watershed. Following the direction of the local steering committee, the BRTAC proceeded to organize and develop the needed information for a voluntary watershed approach to solving resource problems in the watershed. The following stakeholders were involved in developing and reviewing the plan:

Beaver Soil Conservation District
Beaver City
Utah Division of Wildlife Resources
Utah Department of Agriculture & Food
Utah Division of Water Quality, DEQ
Utah State Trust Lands Administration
Bureau of Land Management, USDI
Environmental Protection Agency, Region VIII
Beaver County
Local Citizens
USU Cooperative Extension Service
Utah Association of Conservation Districts
Utah Division of Parks & Recreation
Natural Resources Conservation Service,USDA
U. S. Forest Service, USDA

This document is a Sec. 303(d) TMDL that will be posted on DEQ's website (www.deq.state.ut.us) for public review and submitted to EPA for review and approval.

## 2.0 Problem Characterization

The State of Utah has classified and declared the waters of Beaver River shall be protected for the following uses: Class 3A - cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain; Class 2B - secondary contact recreation; Class 3D - protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain; and Class 4 - protected for agricultural use, including irrigation of crops and stock watering. Current assessments of the Beaver River Watershed indicate that Class 3A beneficial uses are impaired due to excess nutrients, noxious aquatic plants, temperature and habitat alteration (Figure 5).

Sources of nonpoint pollutants include agricultural related activities such as grazing, confined feedlot and dairy operations (Figure 6), irrigation practices, and stream bank trampling from livestock watering in the river. Other sources include urban runoff, summer home development and recreational activities such as fishing, boating, camping and skiing (particularly in the upper watershed).

Figure5  Riparian Area Assessment

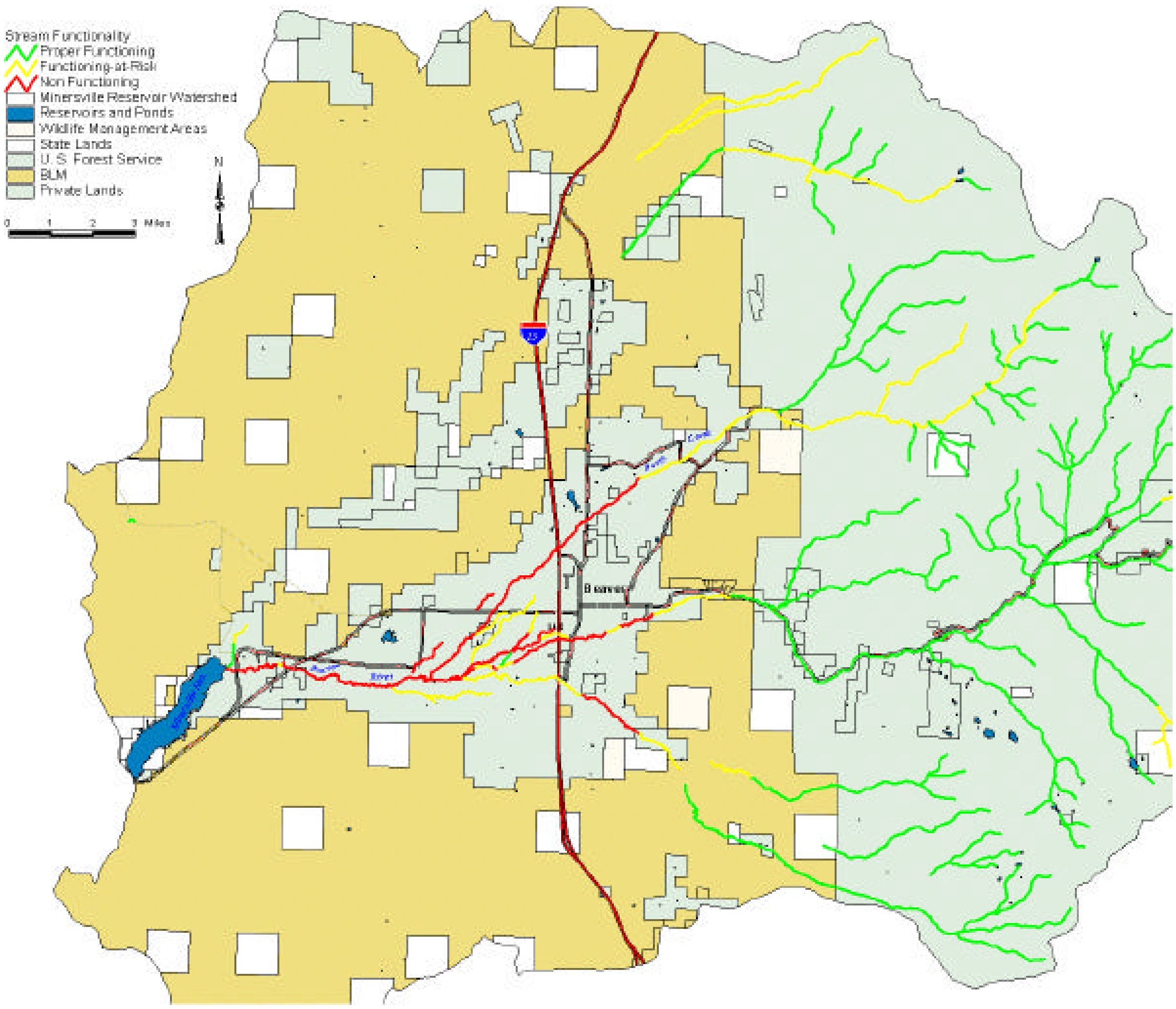
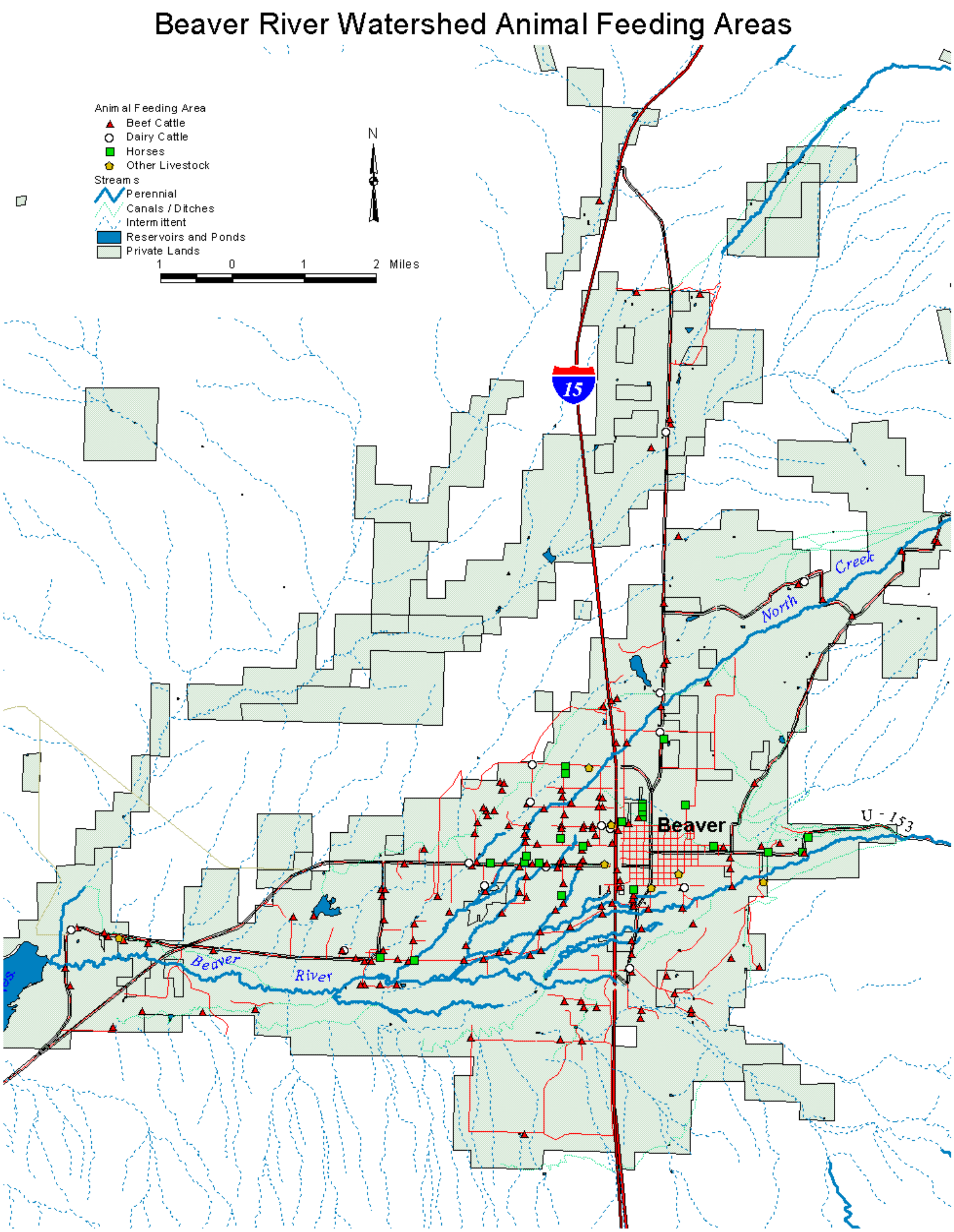


Figure 6 Location of Animal Feeding Areas within the Beaver River Watershed



Approximately 242.2 stream miles were evaluated in the watershed of which only 39 miles (16%) were assessed as fully supporting their Class 3A designated beneficial use while the remaining 203.2 miles (84%) were assessed as partially supporting. However, the Division of Water Quality has reevaluated the stream and tributaries above the USFS boundary under existing criteria and has requested delisting based upon a review of existing data.

Reducing soil erosion and nutrient loading are the primary measures identified to achieve water quality standards and restore beneficial uses for impaired water bodies in this watershed through a voluntary incentive based nonpoint source control program. Sediment is produced from sheet, rill and gully erosion from surrounding rangelands and by stream channel and bank erosion. Local resource experts estimate 2,000 tons of soil per acre are lost annually from rangeland classified in “poor condition”.

Much of the stream channel and bank erosion on the Beaver River occurred during the floods of 1983 and 1984 when a record breaking snow pack combined with a late and rapid spring snow melt. It was estimated that two (2) million tons of sediment were deposited in Minersville Reservoir during this flood. High stream flows are particularly prone to wash sediments, nutrients and other pollutants into the river and tributaries which are then flushed into the reservoir. In the Beaver River Watershed Stream / Riparian Problems and Opportunities section of the CRMP (Petersen et al., 1999) it was estimated that under average runoff conditions channel and bank erosion produce approximately 21,300 tons of sediment per year of which approximately 17,300 tons per year result from accelerated streambank erosion. Approximately 3,600 tons of sediment are yielded annually to Minersville Reservoir, of which approximately 3,100 tons are from accelerated streambank erosion.

Return irrigation flows from pastures and meadows along the Beaver River have been identified as a major source of pollutants entering Beaver River and Minersville Reservoir. Total phosphorous readings averaging 0.137 mg/L have been documented in the river which is almost three times higher than the pollution indicator value of 0.05 mg/L. Lake and reservoir impairment is typically linked to high nutrient loadings which over time results in internal phosphorus loadings from enriched lake bottom sediments. There are currently no permitted discharges in the watershed but there have been discharges in the past from a state fish hatchery and the Beaver municipal waste water system.

**3.0 TMDL Endpoints**

The purpose of the TMDL process is to improve water quality and protect or restore defined beneficial uses. The objective of establishing endpoints is to develop targets that can be tracked during and after implementation and measure progress towards meeting water quality goals and objectives. Waters are defined as impaired after empirical evaluation of available water quality and macroinvertebrate data. This assessment combined with observations from local stewards and water users provides an accurate evaluation of water quality conditions.

Total phosphorus is defined as pollution indicators in the Utah's "Standards of Quality for Waters of the State (R317-2, Utah Administrative Code)." Through the assessment process defined by the Division of Water Quality in compliance with Sec. 305(b) of the Clean Water Act (CWA), additional data is used when available to validate exceedances of pollution indicators. In addition, macroinvertebrate data was obtained at selected stream sites for evaluating impairment of the Beaver River and its tributaries.

Through the implementation of riparian restoration BMPs outlined in the Beaver River Watershed Coordinated Resource Management Plan (CRMP) it is anticipated that at least a 25% reduction in solar radiation reaching the stream can be achieved which will allow the river to meet temperature standards. Practices to be implemented include limiting or excluding grazing from riparian areas through fencing thereby allowing natural re-establishment of vegetative cover (i.e. willows and cottonwoods) and directly establishing vegetation on streambanks through planting. The CRMP identifies these practices primarily to control stream bank erosion but they will also help lower stream temperatures through increased shading after the vegetation is fully established. These practices will be implemented on the sections of Beaver River and tributaries identified as functioning at risk and non-functioning in the riparian area assessment section (Figure 5) of the CRMP.

In order to fully evaluate progress towards the restoration of beneficial uses additional endpoints have been defined, including biological productivity, stream morphology and the biological integrity of the stream and its riparian corridor (Table 3). Linking qualitative endpoints to defined beneficial uses is supported by scientific studies that show these factors affect defined beneficial uses directly or indirectly (e.g. high algal production leads to low dissolved oxygen or anoxic conditions in reservoirs; blue-green algal dominance is indicative of poor water quality; and lack of habitat and streambank stability leads to high sediment loading, and impaired fisheries).

Table 3 TMDL Endpoints for Beaver River Watershed Impaired Waters

| Description | Waterbody Biota | Total Phosphorus concentration mg/L | Dissolved oxygen concentration mg/L | Miscellaneous Endpoints |
|---|---|---|---|---|
| Beaver River and tributaries from Minersville Reservoir to USFS boundary | Shift from organic enrichment and sediment tolerant macroinvertebrates | ≤0.05 | 1day average > 4.0 mg/L | Enhance or restore streambank stability in 24 miles of stream; restore 22 miles of non-functional and 43 miles of at risk riparian areas; develop 80 CNMPs. |
| Beaver River and tributaries from USFS boundary to the headwaters * | Protect or enhance existing macroinvertebrate community | ≤0.05 | 1day average > 4.0 mg/L | |
| Minersville Reservoir | Algal dominance not blue-green | ≤0.025 | 1day average > 4.0 mg/L for > 50% of water column | Overall TSI value 40-50; eliminate grazing below the high water line; inflow concentration ≤ 0.05 mg/L; and all endpoints identified for Beaver River. |
| Kents Lake | Algal dominance not blue-green | ≤0.025 | 1day average > 4.0 mg/L for > 50% of water column | Overall TSI value 40-50 |
| LaBaron Reservoir | Algal dominance not blue-green | ≤0.025 | 1day average > 4.0 mg/L for > 50% of water column | Overall TSI value 40-50 |
| Puffer Lake | Algal dominance not blue-green | ≤0.025 | 1day average > 4.0 mg/L for > 50% of water column | |

* This reach is expected to be removed from the 303(d) list in the year 2000 assessment after further evaluation of the water quality and macroinvertebrate data at the USFS boundary.

### 4.0 TMDL Analysis & Development

The Utah Division of Water Quality, in conjunction with local partners, conducts water quality monitoring in the Beaver River Watershed. A Clean Lakes Phase I study conducted in 1991-92 on Minersville Reservoir and its associated watershed recommended that it be identified as a priority nonpoint source watershed for treatment under Sec. 319 of the CWA. As part of the DWQ's watershed approach this area was included in an intensive monitoring program during 1996-97 and will continue to be monitored every five years at specific sampling sites. Additional stream data is collected annually as part of the Sec. 319 program and lake data is collected biannually under the clean lakes assessment program. This data will be used to evaluate the effectiveness of implemented BMPs and to assess if achievement of defined endpoints is resulting in restored beneficial uses. This on-going water quality monitoring in combination with the conservative assumptions used in the calculations and models of the TMDL, its endpoints, and the prioritization of BMPs will serve as the margin of safety (MOS) required in the development of TMDLs.

The requirement of accounting for seasonality in the development of TMDLs is met through the year-round water quality monitoring program on streams and monitoring during the productivity season on lakes, loading analyses developed from this data, and development of BMPs that specifically deal with seasonal events such as the timing of manure application and irrigation water management plans based upon crop requirements.

Information used to designate impairment in this watershed was obtained and reported in the Minersville Reservoir Clean Lakes Diagnostic and Feasibility Study. Additional information to support the impaired listing status and evaluate the potential for restoration was derived from three sources: water chemistry, instream macroinvertebrate diversity, and mathematical modeling.

Table 4 contains a summary of the percent exceedance for those water quality parameters of concern at specific stream sampling sites in the watershed.

Table 4 Summary of water quality exceedances for parameters of concern in watershed streams

| | Percent Exceedance for period 1993-96 | | | |
|---|---|---|---|---|
| Station | Total Phosphorus 0.05 mg/L | Total Suspended Solids 35 mg/L | Dissolved Oxygen 4 mg/L | Temperature 20$^{o}$C |
| 1) Beaver River at U21 below Minersville Reservoir | 95.5 | 2.3 | 13.6 | 2.3 |
| 2) Beaver River at Rd above Minersville Reservoir | 97.9 | 19.6 | 15.6 | 11.1 |
| 3) Beaver River at U21 above Minersville Reservoir | 97.7 | 16.7 | 4.9 | 17.1 |
| 4) Beaver River above cnfl/w Dry Creek | 100 | 12.5 | 3.1 | 15.6 |
| 5) Dry Creek above the cnfl/w Beaver River | 100 | 18.2 | 27.3 | 0 |
| 6) Big Slough above the cnfl/w Beaver River | 91.7 | 16.7 | 9.1 | 9.1 |
| 7) Beaver River above the cnfl/w South Ck | 97.1 | 2.9 | 6.1 | 6.1 |
| 8) Beaver River at I-15 crossing | 100 | 16.7 | 0 | 0 |
| 9) Beaver River at U-91 crossing | 68.9 | 4.4 | 4.5 | 2.3 |
| 10) Beaver River at USFS boundary | 34 | 6.3 | 0 | 2.1 |

## 4.1 Water Quality Assessment Materials and Methods

### 4.1.1 Field and Laboratory

Data from several sampling sites on the Beaver River was collected approximately every six weeks from 1993 to 1998 as part of the Beaver River Nonpoint Source Project. Some stations were monitored as part of the Minersville Clean Lakes Study and the Sevier River Intensive monitoring program. Lake data was obtained as part of the DWQ routine lake monitoring program for the assessment of priority lakes and reservoirs. Table 5 lists the stream sampling sites, STORET numbers, and site description for those sites selected in this assessment.

Table 5 Sampling locations for assessing stream water quality in the Beaver River Watershed

| Station Number | STORET Number | Sampling Station Description | Stream Classifications | | |
|---|---|---|---|---|---|
| 1 | 594010 | BEAVER R BELOW MINERSVILLE RES AT U-21 XING | 2B | 3A | 4 |
| 2 | 594016 | BEAVER R ABOVE MINERSVILLE RES AT COUNTY RD XING | 2B | 3A | 4 |
| 3 | 594021 | BEAVER R ABOVE MINERSVILLE RES AT U21 XING | 2B | 3A | 4 |
| 4 | 594023 | BEAVER RIVER ABOVE CNFL / DRY CREEK, SOUTH OF GREENVILLE | 2B | 3A | 4 |
| 5 | 594027 | DRY CREEK ABOVE CNFL / BEAVER R SOUTH OF GREENVILLE | 2B | 3A | 4 |
| 6 | 594031 | BIG SLOUGH ½ MILE ABOVE CNFL/ BEAVER R ABOVE COUNTY ROAD | 2B | 3A | 4 |
| 7 | 594033 | BEAVER RIVER ABOVE CNFL / SOUTH CREEK | 2B | 3A | 4 |
| 8 | 594037 | BEAVER RIVER NEAR I-15 XING | 2B | 3A | 4 |
| 9 | 594056 | BEAVER R @ US 91 XING | 2B | 3A | 4 |
| 10 | 594044 | BEAVER R EAST OF BEAVER CITY AT USFS BOUNDARY | 2B | 3A | 4 |

Water quality samples were collected according to standard field procedures defined and adopted by the Division of Water Quality (DWQ, 1993). Sample preservation and laboratory analysis of samples were performed according to EPA approved procedures by the State Health Laboratory. Dissolved oxygen, pH, water temperature, and conductivity were measured *in situ* with a precalibrated Hydrolab instrument. Instantaneous flows were measured using a Marsh-McBurney flow meter during each survey unless the station was located at or near a U.S. Geological Survey (U.S.G.S.) gaging station. Chemical analyses in the laboratory included ammonia, total phosphorus, dissolved nitrate-nitrite, dissolved total phosphorus, total suspended solids, total dissolved solids, dissolved calcium, dissolved magnesium, dissolved potassium, dissolved sodium chloride concentration, sulfate, alkalinity, hardness, and turbidity. Dissolved metal concentrations were also determined in the laboratory for arsenic, barium, cadmium, chromium, copper, iron, lead, selenium, silver, zinc, and mercury.

### 4.1.2 Stream Data Analysis

All water quality sample and field data were entered into and retrieved from the Division of Water Quality's data base. Descriptive statistics, box plots, and regression analyses were obtained using Statistical Analysis System's software program (SAS, 1989). Data were compared with State water quality standards for each stream's designated beneficial uses. Ten sampling stations were evaluated in more detail after preliminary review of the data to determine their suitability for further analysis. If dissolved phosphorus concentrations were greater than total phosphorus, the percent of dissolved phosphorus to total was adjusted to 100%.

All data collected at the ten sampling sites from February 3, 1993 through December 31, 1998 were used to assess support of beneficial uses (Table 6). Only data collected from March 30, 1994 through December 10, 1996 at stations 1, 2, 3, 4, 7, 9, and 10 (unshaded in table) were used for regression analyses and comparisons of total phosphorus, dissolved phosphorus, flows, and total suspended solids since some stations were sampled more than others.

Table 6   Sample collection dates for Beaver River Study

| Date | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Station 6 | Station 7 | Station 8 | Station 9 | Station 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 02FEB93 | | | x | | | | | | | x |
| 16MAR93 | | | x | | | | | | | x |
| 21APR93 | x | x | | | x | x | | x | x | |
| 04MAY93 | x | x | x | | x | x | | x | x | x |
| 20MAY93 | x | x | x | | x | x | | x | x | x |
| 01JUN93 | | | x | | x | x | | x | x | x |
| 02JUN93 | x | | | | | | | | | |
| 14JUN93 | | x | x | | | x | | x | x | x |
| 29JUN93 | x | | | | | | | | | |
| 30JUN93 | | x | x | | x | x | | x | x | |
| 14JUL93 | x | x | x | | x | x | | x | x | x |
| 03AUG93 | x | x | x | | x | x | | x | x | x |
| 18AUG93 | x | x | x | | | | | | | |
| 19AUG93 | | | | | x | x | | x | x | x |
| 01SEP93 | x | x | x | | x | x | | x | x | x |
| 15SEP93 | x | x | x | | x | x | | x | x | x |
| 29SEP93 | x | x | x | | x | x | | x | x | x |
| 23DEC93 | | x | x | | x | | | | | |
| 30MAR94 | x | | x | x | | | x | | x | x |
| 31MAR94 | | x | | | | | | | | |
| 14APR94 | x | x | x | x | | | x | | x | x |
| 28APR94 | x | x | x | x | | | x | | x | x |
| 10MAY94 | x | x | x | | | | x | | x | x |
| 25MAY94 | x | x | x | x | | | x | | x | x |
| 08JUN94 | x | | | | | | | | | |
| 09JUN94 | | x | x | x | | | x | | x | x |
| 06JUL94 | x | x | x | x | | | x | | x | x |
| 17AUG94 | x | | | x | | | x | | x | x |
| 18OCT94 | x | x | x | x | | | x | | x | x |
| 17NOV94 | x | x | x | x | | | x | | x | x |
| 26JAN95 | x | x | x | x | | | x | | x | x |
| 23FEB95 | x | x | x | x | | | x | | x | x |
| 18APR95 | x | x | x | x | | | x | | x | x |
| 18MAY95 | x | x | x | x | | | x | | x | x |
| 31MAY95 | x | x | x | x | | | x | | x | x |
| 21JUN95 | x | x | x | x | | | x | | x | x |
| 11JUL95 | x | x | x | x | | | x | | x | x |
| 02AUG95 | x | x | x | x | | | x | | x | x |
| 29AUG95 | x | x | x | x | | | x | | x | |
| 30AUG95 | | | | | | | | | | x |
| 12SEP95 | x | x | x | x | | | x | | x | x |
| 18OCT95 | x | x | x | x | | | x | | x | x |
| 05DEC95 | x | x | x | x | | | x | | x | x |
| 30JAN96 | x | x | x | x | | | x | | x | x |
| 13FEB96 | x | x | x | x | | | x | | x | x |
| 12MAR96 | x | x | x | x | | | x | | x | x |
| 23APR96 | x | x | x | x | | | x | | x | x |
| 07MAY96 | | | | | | | | | | x |
| 21MAY96 | x | x | | x | | | x | | x | x |
| 20JUN96 | x | x | | x | | | x | | x | x |
| 10JUL96 | x | x | | x | | | x | | x | x |
| 22AUG96 | x | | | x | | | x | | x | x |
| 17SEP96 | x | | x | x | | | x | | x | x |
| 31OCT96 | x | x | x | x | | | x | | x | x |
| 10DEC96 | x | x | x | x | | | x | | x | x |

Only the nonshaded data were used in data analyses between station

## 4.2 Stream Results and Discussion

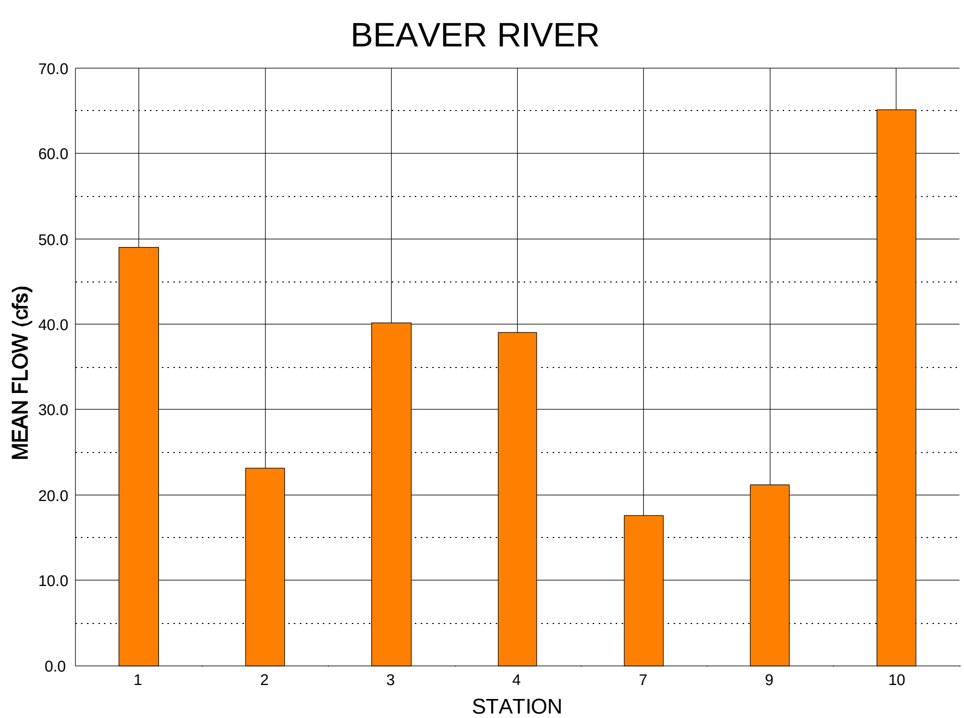
### 4.2.1 State Standards

When data were compared against state standards the Beaver River was found to be fully supporting its agricultural beneficial use classification (Class 4). Contact recreation (Class 2) was not evaluated because no bacteriological data was collected. All stations except Station 10 (Beaver River at the U.S. Forest Service boundary) had high enough concentrations of nutrients to be considered for further study. Data collected for the Clean Lakes and NPS projects indicated that nutrients were a problem in both the Beaver River and Minersville Reservoir. Metals were detected at Stations 3, 7, and 10 but did not exceed State standards.

### 4.2.2 Flow

Mean flows in the Beaver River vary widely between stations (21.2 cfs to 65.1 cfs) due to diversions and contributions from tributaries, springs, seeps and return irrigation flows (Figure 6). Remember that Station 10 is the highest sampling site on the river at the National Forest boundary while Station 1 is below Minersville Reservoir.

Figure 6 Mean Flows in the Beaver River



#### 4.2.3 Total Phosphorus

Mean concentrations of total phosphorus at the 10 stations ranged from 0.046 mg/l to 0.125 mg/l (Figure 7). Mean concentrations are significantly lower at Stations 9 and 10 (upstream) than the other eight stations. The percentage of samples that exceeded the State's indicator of 0.05 mg/l for total phosphorus ranged from a low of 26.5% at Station 10 to 100% at Station 4 (Figure 8). With the exception of Stations 4, 9 and 10 all other stations exceeded the State standard at least 93.9% of the time.

To evaluate the relationship between total phosphorus and sediments a regression was performed on their log-transformed values at each station. Two of the stations showed a significant relationship between these transformed variables but overall the amount of variation accounted for by total suspended solids in total phosphorus data was very low. At Stations 2 and 10, only 34% and 16% of the variation in the amount of total phosphorus was accounted for by total suspended solids. The lack of a clear relationship between sediments and total phosphorus indicates that dissolved phosphorus from irrigation return flows and agricultural runoff are significant sources.

The ratio of dissolved phosphorus to total phosphorus is used to assess whether its origin is organic (dissolved) or associated with sediments. The high ratios (Figure 9) indicating that the primary source of phosphorus is organic.

Figure 7   Box-and-whiskers plot for mean phosphorus data

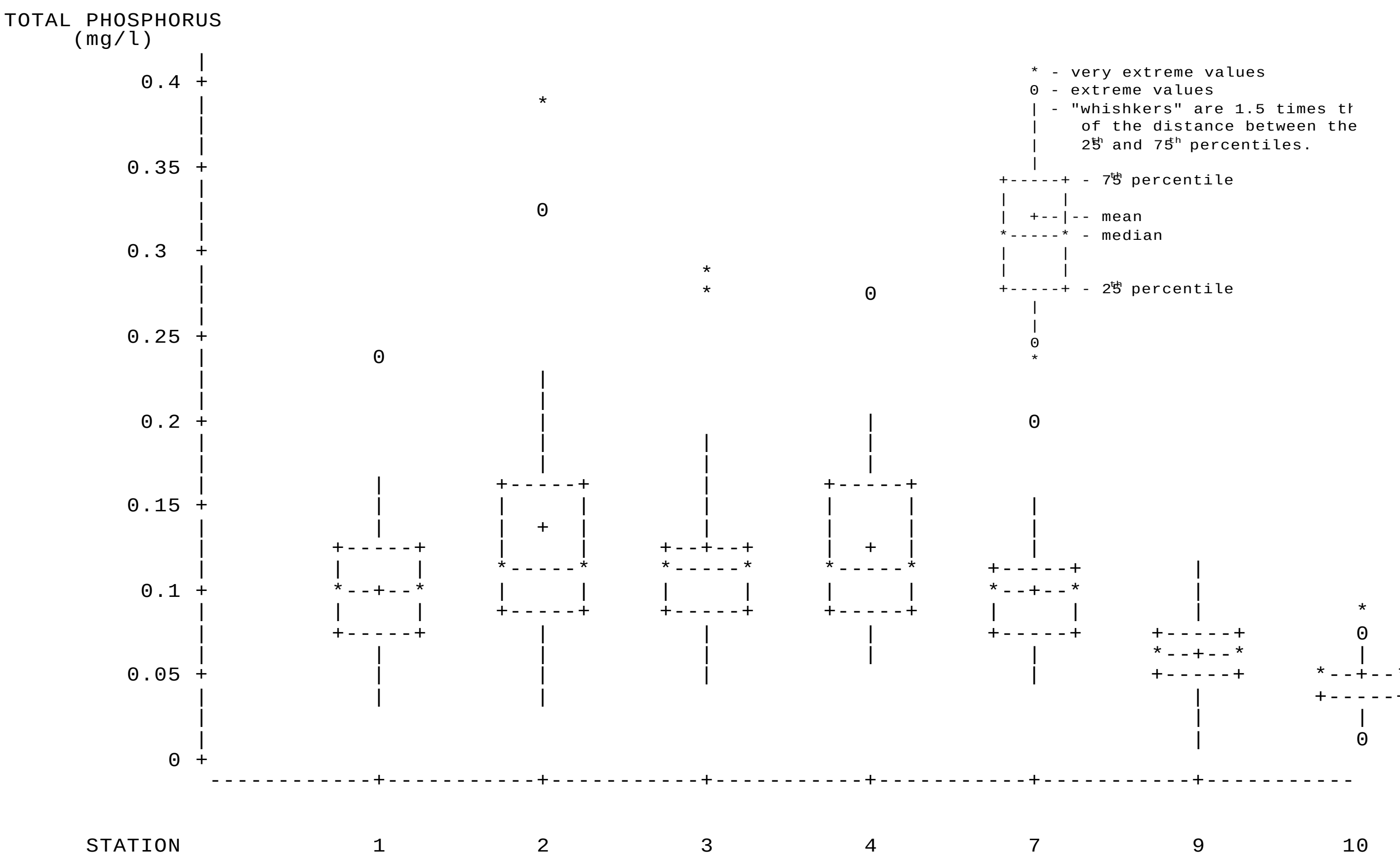


Figure 8  Percent of samples exceeding indicator value of 0.05 mg/L for total phosphorus

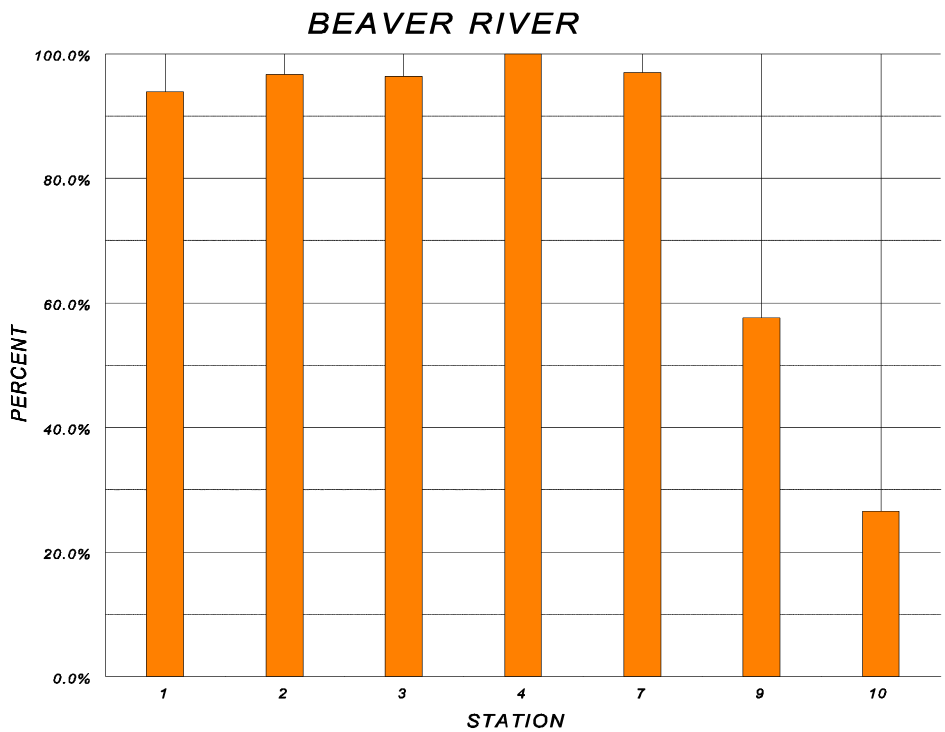
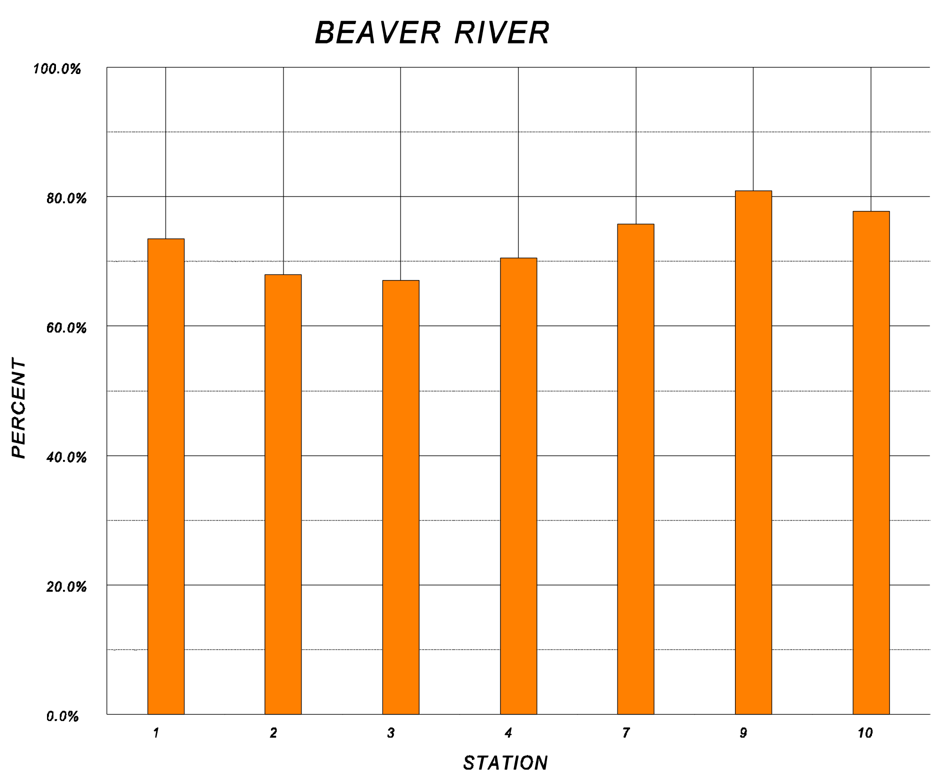



Figure 9  Ratio of dissolved to total phosphorus at ambient sites in watershed



### 4.2.4 Temperature

The following application of a simplified approach in predicting the effect of shading on stream temperatures shows that a 25% reduction in solar radiation will permit the stream to meet its temperature criteria for cold water fisheries.

To determine the effect of restored riparian vegetation on stream temperatures a simple model published in EPA's *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water – Part 1* (1985) was used. The model predicts a stream equilibrium temperature based upon average dewpoint temperature for the critical time period (August), mean daily windspeed and the net incoming solar radiation. The estimated reduction in solar radiation due to stream shading was derived from guidelines set forth by Pluhowski (1968).

$T_d$ (average dewpoint temperature for August) = 6°C
U (mean daily windspeed) = 10 mph
$H_{sn}$ (net incoming shortwave radiation) = 1904 btu/ft$^2$/day

Equilibrium temperature ($E_i$) under unshaded conditions

a. $f(U) = 70+0.7(U^2)$
b. $T=(E_i+T_d)/2$
c. $B=0.255-0.0085(T)+0.000204(T^2)$
d. $K=15.7+(B+0.26)(f(U))$
e. $E_{i+1}=T_d+H_{sn}/K$

The wind speed function f(U) is computed once and the dewpoint temperature ($T_d$) is initially used in place of the equilibrium temperature ($E_i$). If $E_i$ and $E_{i+1}$ differ by more than 1° than $E_{i+1}$ is used in equation b and the procedure is repeated until convergence is attained. After three iterations of the model the equilibrium temperature of the Beaver River under unshaded conditions was found to be 25°C.

After applying a 25% reduction in incoming solar radiation ($H_{sn}$=1428 btu/ft$^2$/day) the new equilibrium temperature was found to be 19°C which meets the state criteria for cold water fisheries.

### 4.2.5 Conclusions and Recommendations

Once the Beaver River leaves the National Forest there is a significant increase in the amount of total phosphorus. Data collected on the Beaver River at the Forest Service boundary indicates that it supports its beneficial uses above this point despite the fact that all waters in the drainage are currently listed. The primary sources of phosphorus are return irrigation flows and runoff from pastures during spring snow melt and rain showers. The Minersville Clean Lakes Study (1995) attempted to determine where the most significant sources of phosphorus were coming from by dividing the watershed into sub-basins but concluded that current data is insufficient to make meaningful delineations. Instead they suggested accepting the premise that farmed/irrigated areas along the Beaver River are contributing significant loads of phosphorus, carefully assessing farming, irrigation, animal feeding concentration, fertilization, etc. practices, and that the general application of BMPs will lead to control of a substantial amount of the nutrients generated by human activities. Finally, it is recommended that sampling and analysis for metals should be conducted quarterly at all stations on a three year cycle to monitor their concentration and for use in the 303(d) assessment.

## 4.3 Macroinvertebrate Analysis

Macroinvertebrate sampling is part of the ongoing monitoring effort in the Beaver River Watershed. Table 7 contains a summary of the macroinvertebrate analysis performed at the National Aquatic Ecosystem Monitoring Center Laboratory. An evaluation of this data at the USFS boundary supports the delisting of Beaver River above this point since the macroinvertebrate community is composed of a high diversity of sediment and nutrient intolerant species.

Table 7 Macroinvertebrate summary at three sites within the watershed (1994-97)

| Macroinvertebrate Analysis at Beaver River above Minersville Reservoir | | | | | |
|---|---|---|---|---|---|
| Date | (DAT) | Mean Standing Crop g/m$^3$ | # of Organisms / m$^3$ | Number of Taxa | BCI |
| 3/30/94 | 10.4 | 5.4 | 29149 | 19 | 52 |
| 10/18/95 | 9.3 | 4.6 | 41910 | 25 | 51 |
| 4/26/96 | 10 | 5.9 | 44219 | 25 | 54 |
| 10/24/96 | 10.3 | 15.7 | 25914 | 25 | 51 |
| 3/20/97 | 4.9 | 3.2 | 10188 | 12 | 51 |
| Macroinvertebrate Analysis at Beaver River above confluence with South Creek | | | | | |
| 3/30/94 | 12.4 | 5.5 | 51678 | 33 | 55 |
| 10/18/95 | 9.5 | 7.4 | 41054 | 22 | 52 |
| 4/26/96 | 9.7 | 8.4 | 31824 | 22 | 54 |
| 10/29/96 | 9.8 | 20.7 | 48188 | 23 | 52 |
| 3/20/97 | 11.3 | 6.7 | 19978 | 26 | 52 |
| Macroinvertebrate Analysis at Beaver River at USFS boundary | | | | | |
| 3/30/94 | 15.6 | 4.6 | 34725 | 36 | 82 |
| 10/18/95 | 11.1 | 1.2 | 9338 | 27 | 72 |
| 4/26/96 | 16 | 4.4 | 17021 | 35 | 81 |
| 10/29/96 | 16.7 | 6.1 | 12021 | 34 | 82 |
| 3/20/97 | 10.8 | 6.8 | 19300 | 23 | 75 |
| DAT = Diversity Index: 18-26 Excellent, 11-17 Good, 6-10 Fair, 0-5 Poor<br>Standing Crop: 4-12 Excellent, 1.6-4 Good, 0.6-1.5 Fair, < 0.5 Poor<br>BCI = Biotic Condition Index: >90 Excellent, 80-90 Good, 72-79 Fair, <72 Poor | | | | | |

## 4.4 Lake Assessments

Determination of beneficial use impairment for lakes was based on several evaluations (Table 8). Initial support status was determined according to the national 305(b) criteria for dissolved oxygen, temperature, and pH. The data for these three parameters is analyzed for the entire water column and a percent of the readings in violation of State standards is determined. Exceedance percentages used to assess support status are those identified in the 305(b) guidelines with the exceptions of dissolved oxygen. Current 305(b) guidelines indicate for any one pollutant or stressor, criteria exceeded in less than or equal to 10 percent of measurements a designation of fully supporting was assigned. For any one pollutant or stressor, criteria exceeded in greater than 10, but less than or equal to 25 percent of measurements a designation of partially supporting was assigned. For any one pollutant or stressor, criteria exceeded in greater than 25 percent of measurements a designation of not supporting was assigned. State standards account for the fact that anoxic or low dissolved oxygen conditions may exist in the bottom of deep reservoirs and therefore, only the upper 75% of the water column is evaluated for dissolved oxygen concentrations against the state standard.

Exceedance criteria for dissolved oxygen have been defined using the 1 day minimum dissolved oxygen concentration of 4.0 mg/L. When the concentration is above the standard for greater than 50% of the maximum water column depth a fully supporting status is assigned. If 25-50% of the water column exceeds the criteria, it is designated as partial supporting and if less than 25% of the water column exceeds the criteria, it is designated as not supporting its defined beneficial use. The criteria value for temperature was less than or equal to 20° C and pH between 6.5 and 9.0.

The overall initial support status is based on an evaluation of all three parameters. If all of the parameters are fully supporting then the initial support status is fully supporting. If two of the three parameters are not supporting then the initial support status is not supporting. All other combinations puts the waterbody into the partially supporting category.

Next there is a modification of the initial support status through an evaluation of the trophic state index (TSI), winter dissolved oxygen conditions with reported fish kills, and the presence of significant blue green algal species in the phytoplankton community. A shift downward of one status occurs if two of the three criteria indicate there is an impairment in water quality.

Historical beneficial use support is also used to determine whether to include the waterbody on the 303(d) list. If a waterbody exhibits a beneficial use that is consistently partially supporting or not supporting, it should be listed on the 303(d) list. However, if a waterbody exhibits a mixture of partially and fully supporting conditions over a period of time it should continue to be evaluated.

Table 8 Summary of Individual Lake Beneficial Use Support

| LAKE DESCRIPTION | ACRES | CLASS | OVERALL SUPPORT STATUS | | | 303d | Conventional Parameters DO, Temp, pH | TSI >50 | Winter DO/ Fish Kills | BG Phyto |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1994 | 1996 | 1998 | | | | | |
| Minersville Reservoir | 990 | 3A | PS | PS | NS | X | NS | | FK | Y |
| Kents Lake | 26 | 3A | | NS | NS | X | PS | Y | DO | Y |
| LaBaron Reservoir | 24 | 3A | PS | NS | NS | X | NS | Y | DO | Y |
| Puffer Lake | 65 | 3A | NS | PS | NS | X | PS | | FK | Y |

## 4.5 Technical Support

Projections were developed for total phosphorus loadings that would create desirable mesotrophic conditions using Carlson's trophic state indices for total phosphorus, transparency and chlorophyll-a concentrations. It was predicted that a total phosphorus concentration of 0.05 mg/L, (the pollution indicator value in Utah's water quality standards) would result in an in-lake concentration of approximately 0.025 mg/L. This in-lake concentration should produce mesotrophic conditions by reducing productivity and eventually lead to improved water quality conditions in the reservoirs.

Methods for identifying and quantifying sources of sediment and phosphorus are well documented in the "Stream/Riparian Problem and Opportunity" section of the Beaver River Watershed CRMP prepared by Mark Petersen, et al. (1999). Information on the contribution of total phosphorus related to agricultural activities is contained in the "Agricultural Resources Committee" section of the CRMP. Both of these sections provide vital baseline information on the potential impact of the two major sources of pollutants to the waters in the watershed. The Beaver River Watershed Steering Committee utilized this information for establishing endpoints or targets to reduce pollutants and restore defined beneficial uses.

A nutrient budget was developed to verify the potential sources of nutrients in the watershed and assist in the determination and prioritization of animal waste projects for Sec. 319 nonpoint source funding (Table 9). The number and types of animals were obtained from field surveys conducted in 1998 and reported in the Agricultural Resources Committee Report for the CRMP. The data estimates an excess of 452,715 pounds of phosphorus is produced from agricultural activities in the lower basin. The development of comprehensive nutrient management plans is urgently needed for agricultural operations in this area to minimize the amount of phosphorus entering waterways. For a more comprehensive discussion of these methods or goals please refer to the specific sections of the CRMP as indicated.

Table 9 Nutrient Budget Summary

| Animal Type | Number Animals | Average Weight | Days in Valley | Total Tons of Manure Produced | Total Lbs of P Produced | Total Kg of P Produced | Total Lbs of P2O5 Produced |
|---|---|---|---|---|---|---|---|
| Dairy, Lact. | 1,800 | 1,400 | 365 | 36,792 | 61,167 | 27,745 | 140,683 |
| Dairy, Dry | 450 | 1,200 | 365 | 8,081 | 9,362 | 4,247 | 21,533 |
| Dairy, Heifer | 900 | 1,000 | 365 | 13,961 | 12,483 | 5,662 | 28,711 |
| *Beef | 6,700 | 1,200 | 180 | 45,587 | 164,981 | 74,835 | 379,456 |
| **Calves | 6,000 | 650 | 180 | 20,358 | 66,690 | 30,251 | 153,387 |
| Horse | 85 | 1,500 | 365 | 1,163 | 2,211 | 1,003 | 5,084 |
| Sheep | 200 | 150 | 365 | 219 | 728 | 330 | 1,675 |
| ***Misc. | 75 | 100 | 365 | 55 | 182 | 83 | 419 |
| * Beef = Mother cows (# includes a variety of animals- some that spend winter and/or summer on the meadows)<br>** Calves = Average weight of small calves & larger feeder cows including young dairy calves<br>*** Misc. = Llamas and Dogs | | | | | | | |
| Crop | Acres | Yield | Units | Lbs of P2O5 Needed | (1)Lbs of P2O5 Produced | (2)Lbs of P2O5 Applied | (3)Excess Lbs of P2O5 |
| *Alfalfa | 6,275 | 4.5 | Tons | 375,559 | | 226,855 | |
| *Oat Haylage | 1,107 | 1.5 | Tons | 8,552 | | 40,217 | |
| **Grass Hay | 1,396 | 3 | Tons | 38,111 | | 18,148 | |
| Pasture, Irr | 7,760 | 2 | Tons | 141,232 | | | |
| | | | | | | | |
| Total | 16,538 | | | 563,453 | 730,948 | 285,220 | 452,715 |

* About 40% of 6,275 acres of alfalfa and 1,107 acres of oat hay have manure applied to them
** About 75% of 1,396 acres of grass hay have manure applied to them

## 5.0 TMDL Allocation of Responsibilities

The most recent effort to quantify total phosphorus loading into Minersville Reservoir occurred as part of the Minersville Reservoir Clean Lakes Study (1995). Data used in determining annual loading rates was extracted from the clean lakes study except as noted (Table 10). The annual flow rates used were as follows:

Long term flow (Acre-feet) = Beaver River (38154) + Furnace Ditch (2785) + Runoff (779) + Precipitation (704) + Groundwater (858) = 43,280; Study Period flow (Acre-feet) = 16,958

Reservoir area grazing in Table 10 refers to grazing in direct proximity to the reservoir after the water has receded by 250 beef cattle for a period of 180 days (Jason Bradshaw, pers comm.). We assumed that 50% of this loading would be available for incorporation into the reservoir's water column. The 1,397 Kg/year from reservoir grazing would yield an additional 0.026 mg/L of phosphorus under average long term flow conditions.

Table 10 Annual Total Phosphorus loading observations and goals

| Beaver River Conc. mg/L | Flow AF | Furnace Ditch Conc. mg/L | Flow AF | Groundwater Conc. mg/L | Flow AF | Area Runoff Conc. mg/L | Flow AF | Precipitation Conc. mg/L | Flow AF | Grazing Cattle | Days Present | Total Load | Input conc. mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.14 | 38,154 | 0.15 | 2,785 | 0.15 | 858 | 0.25 | 779 | 0.01 | 704 | | | Long term | |
| 6,586 | | 515 | | 159 | | 240 | | 9 | | | | 7,509 | 0.141 |
| Loadings based on long-term values | | | | | | | | | | | | | |
| 0.14 | 38,154 | 0.15 | 2,785 | 0.15 | 858 | 0.25 | 779 | 0.01 | 704 | 250 | 180 | Long term | |
| 6,586 | | 515 | | 159 | | 240 | | 9 | | 1,397 | | 8,906 | 0.167 |
| Loadings based on long-term values including estimated load from grazing in proximity to the reservoir | | | | | | | | | | | | | |
| 0.10 | 12,692 | 0.10` | 2,000 | 0.15 | 625 | 0.25 | 836 | 0.01 | 805 | | | 1991-92 | |
| 1,565 | | 247 | | 116 | | 258 | | 10 | | | | 2,195 | 0.105 |
| Loadings based on data from the 1991-92 study period excluding grazing in proximity to the reservoir | | | | | | | | | | | | | |
| 0.10 | 12,692 | 0.10` | 2,000 | 0.15 | 625 | 0.25 | 836 | 0.01 | 805 | 250 | 180 | 1991-92 w/graze | |
| 1,565 | | 247 | | 116 | | 258 | | 10 | | 1,397 | | 3,592 | 0.172 |
| Loadings based on data from the 1991-92 study period including grazing in proximity to the reservoir | | | | | | | | | | | | | |
| 0.05 | 38,154 | 0.05 | 2,785 | 0.04 | 858 | 0.15 | 779 | 0.01 | 704 | | | Input goal 0.05 | |
| 2,352 | | 172 | | 42 | | 144 | | 9 | | | | 2,719 | 0.051 |
| Loadings based on long-term flow data with TMDL concentration goal to the reservoir excluding grazing in proximity to reservoir | | | | | | | | | | | | | |
| 0.05 | 38,154 | 0.05 | 2,785 | 0.04 | 858 | 0.15 | 779 | 0.01 | 704 | 250 | 180 | Input goal | |
| 2,352 | | 172 | | 42 | | 144 | | 9 | | 1,397 | | 4,116 | 0.077 |
| Loadings based on long-term flow data with TMDL concentration goal to the reservoir including grazing in proximity to reservoir included | | | | | | | | | | | | | |
| 0.05 | 38,154 | 0.05 | 2,785 | 0.04 | 858 | 0.15 | 779 | 0.01 | 704 | 250 | 180 | Input goal | |
| 2,352 | | 172 | | 42 | | 144 | | 9 | | 1,397 | | 4,116 | 0.050 |
| Loadings needed based on overall long-term loading goal to the reservoir including grazing in proximity to the reservoir | | | | | | | | | | | | | |

It should be noted that during the 1991-92 study period the average inflow concentration for the Beaver River was 0.102 mg/L of phosphorus while the in-lake concentration was higher at 0.112 mg/L. This may be due in part to animal waste from reservoir grazing which becomes readily available in the spring as the animal waste is inundated by rising water levels .

Table 11 is a summary of the annual loading calculations based on data from Table 10. An example of how these loadings were calculated is as follows:

Loading (Kg/year) = Average concentration (mg/L) * Number of acre-feet/year * 1,233 m3/AF * 1,000 L/m3 * 1 Kg/1,000,000 mg

Example 0.14 mg/L * 38,154 AF/year * 1,233 m3/AF * 1,000 L/m3 * 1 Kg/100,000 mg = 6,586 Kg/year

893.1 is a factor that can be used to multiply concentration (mg/L) times flow (cfs) to yield Kg/year:

cf/sec * 60 sec/min * 60 min/hr * 24 hr/day * 365 day/yr * 28.32 L/cf * 1 Kg/1,000,000 mg = 893.1

Example 0.14 mg/L * 52.7 cfs (38,154 AF) * 893.1 = 6,589 Kg/year

Table 11 Summary of annual total phosphorus loads to Minersville Reservoir

| | Beaver R. Kg/year | Reservoir grazing Kg/year | Furnace Ditch Kg/year | Runoff Kg/year | Precipitation Kg/year | Groundwater Kg/year | Total Loading Kg/year |
|---|---|---|---|---|---|---|---|
| 1991-92 without grazing | 1,565 | | 247 | 258 | 10 | 116 | **2,196** |
| 1991-92 with grazing | 1,565 | 1,397 | 247 | 258 | 10 | 116 | **3,593** |
| Long-term without grazing | 6,586 | | 515 | 240 | 9 | 159 | **7,509** |
| Long-term with grazing | 6,586 | 1,397 | 515 | 240 | 9 | 159 | **8,906** |
| CRMP without grazing | 2,352 | | 172 | 144 | 9 | 42 | **2,719** |
| CRMP with grazing | 2,352 | 1,397 | 172 | 144 | 9 | 42 | **4,116** |

The basis of determining loading endpoints and the allocation of loading reductions for Minersville Reservoir is based on the data in tables 9, 10, and 11, trophic state analysis, and watershed goals. Annual loads to Minersville Reservoir are dependant upon flow, the concentration of total phosphorus in the inflow and grazing in proximity to the reservoir below the high water line.

Annual phosphorus loading into the reservoir can be reduced significantly if grazing in proximity to the reservoir ceases (Table 10). Approximately 1,397 Kg/year or approximately 60% of the permissible loading on a long-term basis can be accounted for by this grazing practice. Therefore it is important that cattle be restricted from grazing below the high water line of the reservoir since their waste is such a significant and direct source of phosphorus.

Further reductions of total phosphorus comes from the implementation of streambank stabilization and riparian habitat improvements along with the implementation of waste management programs for identified animal feeding areas (AFAs) through an incentive based nonpoint source control program. Information on these AFAs related to size, proximity to water and other factors are included in the CRMP report for the purpose of developing priority selection criteria. It is the recommendation of the CRMP that 80 AFAs voluntarily develop and implement comprehensive nutrient management plans to reduce phosphorus loads.

Priority for funding the implementation of BMPs has been given to projects that exhibit the greatest benefit on water quality. Currently the focus is on projects related to controlling animal wastes. The initial allocations for funding has been established at: animal waste projects 60%; water efficiency improvement projects 20%; riparian and streambank restoration projects 15%; and range or upland restoration projects 5%. Each type of project has specific criteria established to rank them according to their impact on improving water quality and contribution towards attaining target endpoints defined in the CRMP.

The allocation of phosphorus loads into the three high elevation lakes, Kents Lake, LaBaron Reservoir, and Puffer Lake was calculated by averaging each lake's TSI values over the last ten years and deriving the total phosphorus (TP) concentrations from the following modification of Carlson's TSI equation:

$$TP\ (ug/L) = e^{x}\ (TSI-4.15\ /\ 14.42)$$

It should be noted that the following analysis is based on conservative estimates of water volume due to a lack of inflow data. As additional data is gathered these estimates may be revised to better reflect phosphorus loading into these lakes. The total phosphorus concentrations equivalent to a TSI value of 45 (17 ug/L, mesotrophic condition) was subtracted from each lake's TP values to determine the reduction in total phosphorus needed. These concentrations were then converted into annual loads by multiplying them by the water volume of the lakes. The following table summarizes the results of the calculations used in obtaining the annual load reductions necessary in the three upper elevation lakes.

Table 12. Annual loading of total phosphorus for Kents Lake, LaBaron Reservoir and Puffer Lake

| | Average TSI values | Average TP values (ug/L) | TP reduction needed for mesotrophy (ug/L) | Summary Total Loading (kg/y) |
|---|---|---|---|---|
| Kents Lake | 64.57 | 66 | 49 | 59 |
| LaBaron Reservoir | 55.86 | 36 | 19 | 6 |
| Puffer Lake | 42.42 | 14 | -3 | - |

From the preceding analysis Puffer Lake does not have a phosphorus reduction allocated to it since it is currently mesotrophic.  However, with the drawdown of the lake during the summer macrophytes become predominate which poses a concern for the overwintering of fish in the lake due to large oxygen demands required for decomposition.  In a 1990 winter survey the reservoir was anoxic and the average concentration of total phosphorus in the water was 381 ug/L which substantiates the fact that oxygen is consumed and phosphorus is released back into the water from sediments and organic decomposition.  Recent summer monitoring has also shown depleted oxygen concentrations in the lower portions of the lake.  Additional winter monitoring of Puffer Lake is needed to determine if anoxic conditions continue to persist.  Possible solutions includes mechanically removing macrophytes, dredging to increase depth and reduce growth, water management strategies to inhibit growth of macrophytes, or introduction of grass carp or other biological mechanisms to reduce or control macrophyte growth.

Kents Lake requires a reduction in total phosphorus loading of 59 kg/y to obtain mesotrophic conditions. There has been a declining trend over the last ten years in TSI values for this lake indicating the need for additional monitoring to determine whether improved grazing management and recreational developments on the forest are resulting in improved water quality.  Nonpoint pollution sources have been identified as livestock grazing in proximity to the reservoir and throughout the watershed and from recreation.  The shoreline and lands surrounding the lake are administered by the Forest Service.  Due to the high amount of recreational use this lake receives, including roads and OHV use, 60% of the 59 kg/y load reduction is allocated to these activities while the remaining 40% is allocated to livestock grazing.  Additional improvements towards water quality will be obtained through the continued management of recreational impacts,  implementation of best grazing management principles, and road maintenance.

LaBaron Reservoir requires a reduction in total phosphorus loading of 6 kg/y to obtain mesotrophic conditions.  Nonpoint pollution sources include grazing, silviculture, construction and recreational development. The reservoir shoreline in 80% publicly owned and administered by the Forest Service and the remaining 20% on the east side is privately owned and being developed into recreational homes.  Due to the high potential of phosphorus loading from home and recreational developments 60% of the load reduction is allocated to these sources.  Control of excess sediments being washed into the reservoir during construction and development activities is critical for improving water quality.  Possible control techniques include the placement of silt fences along the bottom of all construction activities, limiting surface disturbance to the dry summer season, and requiring revegetation promptly after the surface has been disturbed. The remaining 40% of the 6 kg/y TP load reduction is allocated to grazing and silvicultural activities. The implementation of best grazing and silvicultural practices such as proper stocking rates, rest rotation, placing slash perpendicular to the slope, and minimizing the number and length of skid trails will help improve the water quality of LaBaron Reservoir. Table 13 summarizes the load reductions for each lake according to each type of land use activity.

Table 13 Load reductions for Kents Lake, Puffer Lake and LaBaron Reservoir according to land use activities

| | Load reduction (kg/y) | | |
|---|---|---|---|
| | Recreational Use | Livestock Grazing | Construction and Development |
| Kents Lake | 35.4 | 23.6 | - |
| Puffer Lake | - | - | - |
| LaBaron Reservoir | - | 2.4 | 3.6 |

## 5.1 Priority Criteria and Ranking

A priority ranking process is necessary on the Beaver River watershed due to the high demand for government cost share money. The following procedures were developed for ranking animal waste management, improved water efficiency, riparian and streambank restoration, and range/upland revegetation projects for agricultural operations within the lower portion of the watershed. The detailed priority ranking worksheets are located within the Beaver River CRMP.

### 5.1.1 Waste Management Projects

The agricultural lands ranking process accounts for different types of phosphorus related problems including proximity to live water, amount of phosphorus produced by different types of livestock, the density of animals within confined feeding operations, site characteristics that influence phosphorus movement, manure application practices, and irrigation efficiencies. Assumptions used in developing the ranking system were: the closer the phosphorus is to live water the more likely it will enter the water; the more animals on a site the greater the amount of phosphorus produced, thus the greater availability of phosphorus; the higher the concentration of animals the greater the chances for phosphorus to enter the water; and the more site characteristics that favor phosphorus movement the more likely phosphorus will enter the water. Site characteristics that favor phosphorus movement include high soil test phosphorus, low water holding capacity, steep slopes, a hardpan or other restrictive soil layer at shallow depths, frequent flooding, a high water table, extremely high or low permeability, and a large volume of rock in the soil.

Manure application practices affect the amount of phosphorus that enters the water. Practices such as applying manure on frozen and/or snow covered ground, applying it continuously on the same fields causing phosphorus buildup, or applying it without incorporating into the soil all have the potential to cause phosphorus movement. Producers are encouraged to adopt better application practices such as not applying manure on frozen and/or snow covered ground, incorporating the manure within 24 hours to 7 days after application, soil testing, and limiting the amount of manure that is applied to one field.

Another assumption of the ranking process is the lower the irrigation efficiency the greater the chances that phosphorus can enter the water. Recent studies show that organic phosphorus remains in solution better than inorganic phosphorus and thus can move more readily with water.

#### 5.1.2 Water Efficiency Improvement Projects

The major goal of water efficiency improvement projects is to reduce or eliminate the movement of phosphorus into the waterways and to reduce the demands on water from the Beaver River and other streams in the watershed. Project proposals for cost share funding will be ranked according to the increase in irrigation efficiency, increase in alfalfa hay production for irrigated hayland, increase in diversity of forage plants on irrigated pastures, and whether the proposed project contributes significant progress towards achieving TMDL endpoints.

#### 5.1.3 Riparian and Streambank Restoration Projects

The major goal of riparian and streambank restoration projects is to reduce or eliminate the movement of phosphorus into the waterways by stabilizing streambanks and establishing a riparian buffer zone for filtering surface flows prior to entering the stream. The restoration of riparian habitat and streambank stability will also lower stream temperatures and provide habitat for wildlife and establish a more productive fishery in the associated stream reaches. The ranking process includes consideration of long term average flows through the project area, public accessibility, vegetative treatment, fencing and grazing management, presence of wetlands, increase in wildlife habitat, functional status of the stream, connectivity of project area to existing riparian habitat, and whether the project proponent has a conservation plan.

#### 5.1.4 Range and Upland Revegetation/Restoration Projects

The major goal of range and upland revegetation/restoration projects is to reduce or eliminate the movement of phosphorus into the waterways by stabilizing soils through increased vegetation cover and proper grazing management. The ranking procedure is based upon the expected percent increase in range condition class.

### 5.2 Best Management Practice Implementation Goals

The following goals have been adopted by the Beaver River Watershed Steering Committee:

1. Implement a minimum of 80 comprehensive nutrient management plans.
2. Reduce or eliminate grazing below the high water line for impaired reservoirs.
3. Manage pasture grazing to minimize phosphorus runoff potential;
4. Treat tailwater for removal of sediment and phosphorus.
5. Improve irrigation delivery systems on 4,000 acres of land.
6. Restore and protect riparian corridors by streambank stabilization and habitat improvement.
7. Increase vegetative cover and diversity and enhance soil stability for rangelands.

## 6.0 Implementation Schedule

Most implementation of nonpoint source controls will be funded under Sec. 319 of the CWA and with EQIP funds administered by NRCS for private lands. Matching sources for these funds will be the responsibility of the private property owner but assistance will be sought under the direction of the local watershed steering committee. Federal lands where nonpoint source controls are needed will be funded through federally mandated programs or agency budgets.

## 7.0 Post Implementation Monitoring

An ongoing monitoring effort will evaluate the effectiveness of individual nonpoint source projects and ascertain if implemented practices are achieving water quality endpoints or targets for restoring beneficial uses. The selection of endpoints for these lakes is based on restoring their cold water fisheries by reducing nutrient loads. A shift from blue-green algae to diatoms and green algae is indicative of reduced total phosphorus levels. The endpoint of DO concentrations no less than 4.0 mg/L in 50 % of the water column during the critical late summer and late winter periods is directly linked to the protection and survival of cold water fish species. The last endpoint of a Trophic State Index (TSI) value range of 40-50 (mesotrophic conditions) during the productivity period (May - September) is directly linked to nutrient levels in the lakes.

Routine qualitative samples of phytoplankton will be taken from the lakes during August to determine dominance of blue-green algae. Water quality sampling for dissolved oxygen (DO) and trophic state index values (TSI) will be conducted twice a year during the productivity season (May - September) every other year. The water quality parameters used to calculate TSI include chlorophyll-a, secchi depth, and total phosphorous concentration. Dissolved oxygen for the lakes will be measured at one meter intervals through the lake profile at the deep site to evaluate progress towards the endpoint.

During implementation of BMPs a more rigorous sampling schedule will be developed to verify progress towards water quality goals. Modifications of targets and endpoints in the TMDLs will be made based on the results of this monitoring program.

## 8.0 Summary of Required WRAS/TMDL Components

WRAS Components:

| | | |
|---|---|---|
| 1. | Identification of measurable environmental and programmatic goals | YES |
| 2. | Identification of sources of pollutants and relative contribution | YES |
| 3. | Restoration measures to achieve resource goals | YES |
| 4. | Schedule for implementation of restoration measures | YES |
| 5. | Identification of lead agencies to oversee implementation, monitoring, maintenance, and evaluation | YES |
| 6. | Implementation of TMDLs for specific water quality criteria violations | YES |
| 7. | Implementation of source water assessment and protection programs | YES |
| 8. | Monitoring and evaluation plan developed | YES |
| 9. | Funding plans identified for implementation and maintenance | YES |
| 6. | Interdisciplinary coordination for implementation | YES |
| 10. | Public involvement | YES |

TMDL Components

| | | |
|---|---|---|
| 1. | Application of TMDL based on maintaining or attaining water quality standards | YES |
| 2. | TMDLs have identified targets or endpoints | YES |
| 3. | TMDLs includes a quantified pollutant reduction target | YES |
| 4. | All significant sources of the stressor are identified and considered | YES |
| 5. | TMDL is supported by appropriate level of technical analysis | YES |
| 6. | Margin of safety for the TMDL has been identified and discussed | YES |
| 7. | An allocation of responsibility for actions has been identified | YES |
| 8. | Public involvement and review of the TMDL has occurred | YES |